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PATENT SPECIFICATION

609,771

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PROVISIONAL SPECIFICATION

Improvements relating to the Manufacture of Bladed Turbine Discs, Compressor Rotors or the like

We, POWER JETS (RESEARCH AND DEVELOPMENT) LIMITED, a British Company, of 8, Hamilton Place, London, W.1, and TRISTRAM ALLAN TAYLOR, a British Subject, of the said Company's address, do hereby declare the nature of our invention to be as follows:—

This invention relates to improvements in the manufacture of bladed turbine discs, compressor rotors or like articles, for example for use in gas turbine engines and its object is to enable complex structures of this kind to be made more easily and rapidly than hitherto. In the previously known methods of manufacture of such articles it is necessary to carry out a number of difficult and complex machining processes, and the object of the invention is to enable for example a turbine disc complete with blades or similar complex structures to be cast in one piece so that these machining processes are eliminated. Units such as axial compressors may be built up by casting the individual stages and assembling them together on a suitable shaft, or if so desired all stages may be cast as one piece.

According to the invention a bladed turbine disc, compressor rotor or like structure is made by preparing a wax model of the said structure, spraying said model with a solution containing finely ground refractory material in suspension, preparing a mould from the wax model, introducing molten metal into said mould, and subsequently spinning said mould about a vertical axis to form a centrifugal casting.

The mould may be made from refractory material and a binding liquid in the form of a liquid suspension or slurry which is poured into a container surrounding the wax model until the latter is completely immersed. The assembly is then placed on a vibrating table until the mould material has set hard. Setting may be accelerated by the addition of a suitable alkali to the mix, such as magnesium oxide or other basic oxide. After the mould has been hardened the wax model may be removed by heating the mould to melt or burn away the wax.

The suspension used for spraying the wax model is suitably chosen to give the casting a good surface finish. A suitable mixture to use may for example comprise a suspension of silica or other refractory oxide or silicate in a solution containing sodium silicate or ethyl silicate as a binder.

In applying the invention in detail one process of manufacture according to the invention as applied to a bladed turbine disc is as follows. A wax model of the turbine disc and blades is first made. This may be done by means of a master pattern from which a master mould is prepared. By injecting melted wax into this master mould and allowing the wax to set, a wax model is obtained. The complete wax model may be made at one injection into a suitable die or may be built up by welding together individual wax components made separately in dies of simpler construction, e.g. in making a wax model of a turbine the blades and disc may be made separately and afterwards welded together while located in a suitable fixture. This model is then sprayed to give it a surface coating which may for example, consist of a suspension of silica in a sodium or ethyl silicate solution.

The liquid is allowed to dry (for example at normal air temperature) and the wax model is then placed in a container which is filled with a liquid composition or slurry which when allowed to stand at room temperature or heated for several hours at a temperature of about 40—50° C. with or without the use of a vibrating table will form a hard refractory mould. The mould is then heated slowly to a temperature of about 700° C. or over so as to melt the wax and completely burn it away. The result of this procedure is to produce a refractory pre-

[*Price* 2/-]

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cision mould which can then be used for containing molten metal.

The mould is then heated to a temperature which is adjusted to be suitable for the material being cast into it, e.g. for steels and other metals of high melting point the temperature may be raised to 1000°—1300° C. while for metals of lower melting point the mould temperature may be reduced to any desired value down to room temperature.

The molten metal is poured into the hot refractory mould which is secured to a suitable support and the latter is rapidly spun so as to create sufficient centrifugal force to fill completely the mould cavity or cavities and give the final casting its desirable metallurgical properties.

The mould is then allowed to cool until the metal has solidified and the refractory mould is then destroyed, for example by subjecting it to a few sharp blows with a hammer. The composition of the slurry composing the mould material is so chosen that the mould has sufficient mechanical strength to withstand the centrifugal forces and the impact and erosion of the molten metal, yet is not so strong that it cannot be easily removed from the casting.. A suitable composition for this purpose may for example be

Solid refractory material - 10 lbs.
Liquid - - - - - - - - 1 litre

The solid refractory material may be composed of 60% calcined fireclay "grog" and 40% silica flour, a suitable grading for which is as follows:—

Grog
B.S.S. Sieve

On 10 size mesh - - - - - -	2%
Through 10 on 30 - - - - -	20%
,, 30 ,, 60 - - - - -	18%
,, 60 ,, 100 - - - - -	17%
,, 100 ,, 170 - - - - -	20%
,, 170 - - - - -	Remainder

Silica Flour
All through 200 B.S.S. Sieve

The liquid may conveniently consist of:—

25% tetre ethyl silicate
50% alcohol or methylated spirit)
25% a solution of 15% concentrated hydrochloric acid in 80% aqueous alcohol.

The result of this process is to produce a bladed turbine disc having the required metallurgical properties and a good finish and complete in a single casting which may if desired be given a final additional finish, such as by mechanical or electrolytic polishing, and the turbine disc is then in suitable form for mounting in a steam or gas turbine or other prime mover.

Dated this 21st day of March, 1946.
For the Applicants:
F. J. CLEVELAND & COMPANY,
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Chancery Lane, London, W.C.2.

COMPLETE SPECIFICATION

Improvements relating to the Manufacture of Bladed Turbine Discs, Compressor Rotors or the like

We, POWER JETS (RESEARCH AND DEVELOPMENT) LIMITED, a British Company, of 8, Hamilton Place, London, W.1, and TRISTRAM ALLAN TAYLOR, a British Subject, of National Gas Turbine Establishment, Whetstone, near Leicester, formerly of the said Company's address, do hereby declare the nature of our invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to improvements in the manufacture of bladed turbine discs, compressor rotors or like articles, for example for use in gas turbine engines and its object is to enable complex structures of this kind to be made more easily and rapidly than hitherto. In the previously known methods of manufacture of such articles, it is necessary to carry out a number of difficult and complex machining processes, and the object of the invention is to enable for example a turbine disc complete with blades, or a similar complex structure to be cast in one piece, so that these machining processes are eliminated. Units such as axial compressors may be built up by casting the individual stages and assembling them together on a suitable shaft, or if desired all stages may be cast as one piece.

According to the invention a bladed turbine disc, compressor rotor or like structure is made by preparing a wax model of the said structure, coating said model

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with a solution containing finely ground refractory material in suspension by spraying or dipping, preparing a mould from the wax model, introducing molten metal into said mould, and subsequently spinning said mould about a vertical axis which is also the axis of said body to form a centrifugal casting.

The mould may be made from refractory material and a binding liquid in the form of a liquid suspension or slurry which is poured into a container surrounding the coated wax model until the latter is completely immersed. The assembly may then be placed on a vibrating table to remove any entrapped air bubbles, and to consolidate the mould material. Setting time is governed by the composition of the binding liquid and may be accelerated by the addition of a suitable refractory material and alkali to the mix, such as magnesium oxide or other basic compound. After the mould has been hardened the wax model may be removed by heating the mould to melt or burn away the wax.

The suspension used for coating the wax model is suitably chosen to give the casting a good surface finish. A suitable mixture to use may for example comprise a suspension of silica or other refractory oxide or silicate in a solution containing sodium silicate or ethyl silicate as a binder.

In applying the invention in detail one process of manufacture according to the invention as applied to a bladed turbine disc is as follows. A wax model of the turbine disc and blades is first made. This may be done by means of a master pattern from which a master mould is prepared. By injecting melted wax into this master mould and allowing the wax to set, a wax model is obtained. The complete wax model may be made at one injection into a suitable die or may be built up by welding together individual wax components made separately in dies of simpler construction e.g. in making a wax model of a turbine, the blades and disc may be made separately and afterwards welded together, while located in a suitable fixture. This model is then sprayed to give it a surface coating which may for example, consist of a suspension of silica in a sodium or ethyl silicate solution.

The liquid is allowed to dry (for example at normal air temperature) and the wax model is then placed in a container which is filled with a liquid composition or slurry, which when allowed to stand at room temperature or heated for several hours at a temperature of about 40—50° C. with or without the use of a vibrating table will form a hard refractory mould. The mould is then heated slowly to a temperature of about 700° C. or over, so as to melt the wax and completely burn it away. The result of this procedure is to produce a refractory precision mould which can then be used for containing molten metal.

The mould is then heated to a temperature which is adjusted to be suitable for the material being cast into it, e.g. for steels and other metals of high melting point, the temperature may be raised to 1000°—1300° C. while for metals of lower melting point the mould temperature may be reduced to any desired value down to room temperature.

The molten metal is poured into the hot refractory mould, which is secured to a suitable support and the latter is rapidly spun so as to create sufficient centrifugal force to fill completely the mould cavity or cavities and give the final casting its desirable metallurgical properties.

The mould is then allowed to cool until the metal has solidified and the refractory mould is then destroyed, for example, by subjecting it to a few sharp blows with a hammer. The composition of the slurry composing the mould material, is so chosen that the mould has sufficient mechanical strength to withstand the centrifugal forces and the impact of and erosion by the molten metal, yet is not so strong that it cannot be easily removed from the casting. A suitable composition for this purpose may, for example be

Solid refractory material - 10 lbs.
Liquid - - - - - - - - 1 litre

The solid refractory material may be composed of 60% calcined fireclay "grog" and 40% silica flour, a suitable grading for which is as follows:—

Silica Flour
All through 200 B.S.S. Sieve

Grog
B.S.S. Sieve

On 10 size mesh			2%
Through 10	on 30		20%
,, 30	,, 60		18%
,, 60	,, 100		17%
,, 100	,, 170		20%
,, 170			Remainder

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The liquid may conveniently consist of:—

25% tetre ethyl silicate
50% alcohol or methylated spirit)
25% a solution of 15% concentrated hydrochloric acid in 80% aqueous alcohol.

The bladed turbine disc found by the above described process may, if desired, be given a final additional finish, such as by mechanical or electrolytic polishing, before mounting it in a steam or gas turbine or other prime mover.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A method of producing a rotary bladed body, such as a bladed turbine disc or compressor rotor comprising forming a wax model of said body, spraying said model with a liquid containing finely ground refractory material in suspension, preparing a mould from the wax model, introducing molten metal into said mould and spinning said mould about a vertical axis which is also the axis of said body.

2. A method as claimed in Claim 1 wherein the liquid is a solution containing sodium or ethyl silicate containing a suspension of a refractory oxide or silicate for example silica.

3. A method as claimed in Claim 1 or 2 wherein the mould is of refractory material and is formed by pouring a liquid suspension or slurry over the coated wax model in a suitable container and subsequently setting or hardening said suspension or slurry.

4. A method as claimed in Claim 3 wherein the suspension or slurry comprises a solid refractory material and a liquid in the proportion of 10 lbs. to 1 litre respectively, the solid being composed of 60% calcined fireclay grog and 40% silica flour.

5. A method as claimed in Claim 4 wherein the liquid comprises tetra ethyl silicate, alcohol and a solution of concentrated hydrochloric acid in alcohol.

6. A method as claimed in Claim 4 wherein the liquid is composed of 25% tetra ethyl silicate, 50% alcohol and the remainder a solution of 15% concentrated hydrochloric acid in 80% aqueous alcohol.

7. A method as claimed in Claim 4, 5 or 6 wherein the silica flour all passes through a sieve of British Standard Size 200, while the grog has the following grading:—

B.S.S. Sieve

On 10 size mesh	- - - - -		2%
Through 10 on	30 - - - -		20%
,, 30 ,,	60 - - - -		18%
,, 60 ,,	100 - - - -		17%
,, 100 ,,	170 - - - -		20%
,, 170	- - - -		Remainder

8. A method of producing a rotary bladed body substantially as hereinabove described.

9. A rotary bladed body produced by the method claimed in any one of the preceding claims.

Dated this 3rd day of April, 1947.

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